The hidden message in Maxwell's equations

Did Maxwell lodge with his bank the answer to his mathematical bluff, Maxwell's Equations, with instructons to open and publish a century later? And did the bank lose the envelope?

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Historically, the theory of electrodynamics grew out of the theory of static fields, electric and magnetic. These static fields resulted from steady electric currents and static electric charge. Maxwell wrestled with the paradox of the capacitor[1,2], and this led him to reassert Faraday's idea of "the propagation of transverse [electro] magnetic [waves][3]." So the concepts of electric charge and electric current preceded the concept of a transverse electromagnetic wave[4], and it is generally agreed (but not by me) that the t.em. wave follows from the prior postulation of electric charge and current[1,2].

A strong case can be made for the view that the t.em. wave is a more fundamental Primitive, or starting point, for electromagnetic theory than electric charge and electric current.

- When light and heat reach us from the sun, it is by the mechanism of a t.em. wave, not electric charge and current.

by Ivor Catt

- Kip[5] says that the energy dissipated in a resistor entered it *sideways*, and was transported into the resistor by the t.em. wave.
- In 1898 J.A. Fleming[6] wrote that 'although we are accustomed to speak of the current as flowing in the wire,. . ., (it) is, to a very large extent, a process going on in the space or material outside the wire.'
- In *Wireless World*, May 1985, page 18, in a reply to G. Berzins, I showed that the t.em. wave, not the electric current, must be the mechanism by which energy is transferred.

- We all adhere to the underlying primitive 'conservation of energy'. Now energy is transported by the t.em. wave, not by electric charge and electric current.

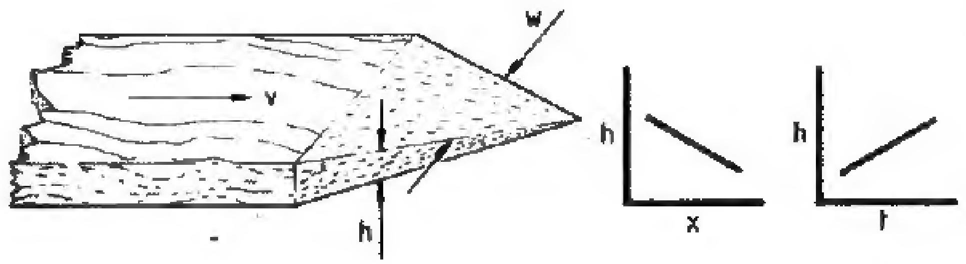
- We all adhere to the underlying relativistic primitive, 'no instantaneous action at a distance'. While electric *charge* could be argued to be located at only one point in space-time, this is not true of an electric current, some of which is necessarily located at the same time at points which in the language of Minkowski are 'elsewhere' to itself.

Catt's equations of motion for a tapering wooden plank

Consider a plank of wood tapering to a point at the front, travelling at velocity v. The aspect ratio of the wood's cross section is z. Height and width at any point are denoted by h and w. Within the tapering section, the ratio of height to width remains z.

The velocity of the plank is the factor which relates the change of height with forward distance to the change of height at a point with time, so from first pinciples, we can write

$$\frac{\partial h}{\partial x} = -\frac{1}{v}\frac{\partial h}{\partial t} \text{ *(refs 7,8)}. \qquad 1$$



Since we have stated that at any point, h/w = z, we can substitute for h in equation 1:

$$\frac{\partial h}{\partial x} = -\frac{z}{v}\frac{\partial w}{\partial t}. \qquad 2$$

Again from first principles, we can write

$$\frac{\partial w}{\partial x} = -\frac{1}{v}\frac{\partial w}{\partial t}. ^{*} \qquad 3$$

In the same way as we substituted for h in equation 1 to get (2), now substitute for w, to get

$$\frac{\partial w}{\partial x} = -\frac{1}{vz}\frac{\partial h}{\partial t}. \qquad 4$$

Equations 2 and 4 we define as Catt's Equations of Motion for a wooden plank. Note that they hold true for any type of taper, and even for a straight portion of the plank, when both sides of the equations are equal to zero. The only imposed limitation is that h remain proportional to w.

* For explanation of the minus sign, see ref.9.

Catt's equations of motion for a thick warm plank

We postulate that a thick plank of wood travels forward with velocity v. At every point within the plank, we postulate that the temperature T is proportional to the density of the wood ρ, so that $T/\rho = z$. (To picture this, think of spontaneous combustion.)

Catt's equations 2 and 4 now become

$$\frac{\partial T}{\partial x} = -\frac{z}{v}\frac{\partial \rho}{\partial t} \qquad 5$$

$$\frac{\partial \rho}{\partial x} = -\frac{1}{vz}\frac{\partial T}{\partial t} \qquad 6$$

These equations remain valid for two thick short planks moving forward side by side.

Maxwell's equations compared with two thick short planks

Let us first review two of the many extant versions of Maxwell's Equations for a vacuum.

$$\frac{\partial E}{\partial x} = -\frac{\partial B}{\partial t} \qquad 7$$

$$\frac{\partial H}{\partial x} = -\frac{\partial D}{\partial t} \qquad 8$$

The version above has been obscured by the introduction of alternative symbols B and D to denote magnetic and electric fields. Our purpose is more easily served if we use another of the many versions that litter the text books (ref. 2):

$$\frac{\partial E}{\partial x} = -\mu_0\frac{\partial H}{\partial t} \qquad 9$$

$$\frac{\partial H}{\partial x} = -\epsilon_0\frac{\partial E}{\partial t} \qquad 10$$

Our problem is that whereas the equations for planks have constants v for velocity and z for ratio, Maxwell's Equations have the obscure symbols μ_0 and ϵ_0. However, this problem becomes trivial because it is known from experiment that

- the velocity of light or a t.em wave is $c = 1/\sqrt{\mu_0 \epsilon_0}$
- the ratio between E and H at any point, described by the symbol Z_0, has been found by experiment to be equal to the constant $\sqrt{(\mu_0/\epsilon_0)}$.

By algebra, we find that $\mu_0 = Z_0/c$ and $\epsilon_0 = 1/cZ_0$ (ref. 10). We can now see that equations 9 and 10 are in fact 5 and 6, Catt's equations for two thick short planks, and contain virtually no information about the nature of electromagnetism.

The hidden message in Maxwell's equations

In general, Maxwell's Equations tell us only the obvious truisms about any body or material moving through space. It is the obscurantism of the fancy maths in which they are dressed that has for the last century caused scholars to think that they contain significant information about the nature of electromagnetism (but see refs 7 and 9). Most versions are far more messy and obscurantified than the two comparatively

clean versions (7) through (10) listed above. Other versions tend to contain a mixture of integrals, divs, curls, and much more, leading to a head-spinning brew, see for instance refs 1,13. (For the Inscrutable Ultimate, see panel for Chen-To Tai.)

Two questions arise:

— do Maxwell's Equations contain any information *at all* about the nature of electromagnetism?

— why do academics and practitioners generally believe that Maxwell's Equations are useful?

The answer to one of these turns out to be much the same as the answer to the other.

Returning to equation 1, this is only valid if the constant in the equation equals the velocity of propagation v. When we then mix together h and w to produce the hybrid equations 2 and 4, they only remain true if h and w are always in fixed proportion z. So we find that Maxwell's Equations 9 and 10 are only true if at every point in space E is proportional to H, and also if the velocity of electromagnetism has the fixed value c. So the only information about electromagnetism contained in the apparently sophisticated equations 9 and 10 is about the two ruling constants in electromagnetism: the fixed velocity c, and that E,H at every point are in fixed proportion Z_0. The remaining content of Maxwell's Equations is hogwash.

We have to conclude, with respect, that what Maxwell and his sycophants do not say about a tapering, disappearing plank of wood isn't worth saying.

Now move on to the second question, "Why do academics and practitioners generally believe that Maxwell's Equations are useful?" The answer to this question, deriving from the previous discussion, is extraordinary. We have already seen that Z_0 and c are the only items of information buried in Maxwell's Equations. We resolve the paradox by pointing out that

> Z_0 is not available as a concept to the whole of the fraternity called 'modern physics'.

The only way they can use such a necessary constant in their work is by taking on board with it all the meaningless rubbish in Maxwell's Equations which shrouds this valuable nugget.

In September 1984, in a paper delivered to a learned conference[11] and in that month's issue of *Wireless World*, I wrote: "It is noteworthy that Einstein himself and also the whole post-Einstein community who call themselves 'modern physics' never mention the impedance of free space $\sqrt{\mu_0/\epsilon_0}$, although it is one of the key primitives on which digital electronic engineering is based. The reader is encouraged to look for reference to it in the literature of 'modern physics'." Since then, no one has pointed out any case where it is mentioned in the literature. It follows that

The only purpose served by Maxwell's Equations is as a package to deliver the constant Z_0 to the theorist and to the practitioner.*

If they lacked another source for it, c could also be accessed via Maxwell's Equations, but I think that to some extent c is available via other routes, although university lecturers remain muddled and vague about the velocity of a t.em. wave. Curiously, they are much more sure that the velocity of light equals the constant c.

Did Maxwell lodge with his bank manager the answer to his mathematical bluff, Maxwell's Equations†, with instructions to open and publish a century later? Did his bank lose the envelope? Should we say to Maxwell now, as he sits laughing, or perhaps smarting, on Cloud Nine, "Now pull the other leg?" No. I am sure that Maxwell was sincere, and did not knowingly shroud the very heart and soul of science, Electromagnetism, in confusion and nonsense for over a century.

* A bit like burning down your house to get roast pig.

† The meticulous student might like to follow up the assertion by H. J. Josephs that Heaviside, not Maxwell, wrote Maxwell's Equations. Is it true that Maxwell's writings do not contain Maxwell's Equations? This issue does not effect the discussion. Certainly my hero Heaviside fell hook, line and sinker for Maxwell's Equations. Nobody's perfect. According to Dr D.S. Walton, "The physical substance is in Maxwell's writings, but the formal expression that we are familiar with is due to Heaviside".

Appendix

It is worth repeating here from ref. 7 that the following two source equations, from which Maxwell's Equations are derived, have never been mentioned in the literature:

$$\frac{\partial E}{\partial x} = -Z_0 \epsilon_0 \frac{\partial E}{\partial t}$$

$$\frac{\partial H}{\partial x} = -\frac{\mu_0}{Z_0}\frac{\partial H}{\partial t} .$$

These are similar to equations 9 and 10. The alternative form is

$$\frac{\partial E}{\partial x} = -Z_0 \frac{\partial D}{\partial t}$$

$$\frac{\partial H}{\partial x} = -\frac{1}{Z_0}\frac{\partial B}{\partial t} .$$

These are similar to equations 7,8. The cross-linkage of electric and magnetic fields E and H in Maxwell's Equations only obscures the issue. There is no interaction between E and H. (Similarly the *width* of a brick does not interact with its *length*.) They are co-existent, co-substantial, co-eternal (refs 12,14).

Historical background reading

What did Maxwell do? What did he say that he did? Today, what do scientists believe that he did?

Did Maxwell postulate 'The Extra Current', now called Displacement Current, to resolve an anomaly which arose from the capacitor in a closed circuit? Or did he later falsely claim it as his reason? Or is it merely the false reason given in the history books? It is possible to argue that for my purpose these distinctions are unimportant, because if unknown, they do not influence the contemporary scene. (All the same, I believe that the true history of science is very important.)

Generally, I attemp to bypass these niceties, in order to create an uncluttered discussion of the technical flaws in today's science. By contrast, historians, lacking proficiency in electromagnetical theory, assume that today's situation is sound, and the only problem is that there are errors in our knowledge as to how we reached it.

This difference — that I am concerned with flaws in the contemporary body scientific and less concerned with historical detail — creates an uneasy relationship between the historians and me. As a result, I both do and do not want to point the reader to historical analysis of Maxwell exemplified by the following:

Chalmers, A.F., Maxwell and the displacement current, *Physics Education*, vol.10 1975, p.45

Gee, B., Models as a pedagogical tool: can we learn from Maxwell? *Physics Education*, vol.13, 1978, p.287.

Tai, Chen-To, On the Presentation of Maxwell's Theory, *Proc. IEEE*, vol.60, no.8, Aug.1972, p.936.

References

1. Carter, G.W., The Electromagnetic Field in its Engineering Aspects, Longman, 1954, p.313.
2. Kip, A.F., Fundamentals of Electricity and Magnetism, McGraw-Hill, 1962, p.312.
3. *ibid*, p.314. Kip quotes Maxwell as saying that Faraday proposed transverse waves.
4. Catt, I., et al., History of displacement current, *Wireless World*, March 1979, p.67.
Catt, I., The Heaviside signal, *Wireless World*, July 1979, p.72.
5. ref.2, p.327.
6. Fleming, J.A., Magnets and Electric Currents, 1898, p.80, quoted in *Wireless World*, Dec. 1980, p.79.
7. Catt, I., Maxwell's equations revisited, *Wireless World*, March 1980, p.77.
8. Catt, I., Electromagnetic Theory, C.A.M. Publishing, 1979, pp30,97.
9. *ibid*, pp.112, 281, 313.
10. ref. 8, p.237.
11. Catt, I., The Fundamentals of Electromagnetic Energy Transfer, International Conference on Electromagnetic Compatibility, Surrey University, IERE Pub. 60, Sept. 1984, p.57.
12. ref. 4, 2nd item also Oct. 1984.
13. Plonsey, R. and Collin, R.E., Principles and Applications of Electromagnetic Fields, McGraw-Hill, 1961, pp.301,311. Also Chen-To Tai (see panel).
14. Catt, I., Letter *Wireless World*, Feb. 1984, p.51.